Draft
Lamprey River
Proposed Protected Instream Flow Report

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Report

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EXECUTIVE SUMMARY

This report describes the scientific process used to develop protected flows for the Lamprey Designated River. The following discussion summarizes the scientific basis for the protected flows.

Protected Instream Flows were defined in the study for flow-dependent protected entities listed in RSA 483. These protected entities can be grouped as fish, riparian wildlife and vegetation, and human uses. Protected instream flows for fish were developed using MesoHABSIM, a habitat simulation model, and those for riparian wildlife and vegetation were developed using a floodplain transect survey method. Flow needs for the human recreational (boating and swimming) and water supply uses of flow were developed using questionnaires and surveys. The flow requirements for fish, riparian wildlife and vegetation were found to be the determinant factors for instream flow protection because of their dependence on specific flow magnitude, duration and frequencies to support habitat and life cycle needs. The human recreational uses of flow are considered to be opportunistic, meaning that boating and swimming are seasonal uses supported by recurring natural flows. The use of the Lamprey River as a water supply source is also considered to be flow dependent since sufficient flow must be available to meet public water supply needs.

Protected flows for fish and riparian wildlife and vegetation were compiled to describe the Lamprey Designated River's protected flows. The resulting protected flows were developed and evaluated within the framework of the Natural Flow Paradigm. Maintaining these flows will protect human uses by maintaining the natural hydrograph variability.

Natural Flow Paradigm

The development of the protected instream flow (PISF) values was performed within the framework of the Natural Flow Paradigm (Poff and others, 1997). The Natural Flow Paradigm recognizes that the natural variability of stream flows is what determines the geomorphic and biologic characteristics of a stream or river. The native riverine ecosystem adapted to a natural flow regime that was not affected by diversions, discharges or withdrawals. Too great a change from the natural flow regime will cause impairment of the ecosystem; however there is flexibility within the variability for water use. The Natural Flow Paradigm also recognized that minimum flows were not adequate for describing the natural variability of flows. Flow has other components beside magnitude that are important to sustaining the ecosystem. Description of protected flows requires the use of the components of the Natural Flow Paradigm: flow magnitude, frequency, duration, timing and rate of change.

The application of the Natural Flow Paradigm concept in this study implies that the principal management objective is to allow streams to flow as close to its natural flow regime as possible. Low flows and floods are expected to occur as natural conditions and occur within the range of natural flows. Typical human influences tend to reduce flow variability by removing floods and droughts. This may make the availability of stream flow more reliable for human use, but is detrimental to biological integrity. Understanding the potential for the human alteration of the natural flow regime of the Lamprey River and the impact on its protected entities is a major objective of this study.

It is important to recognize that the natural river flow (even in the absence of any human intervention or water use) will not always meet all of the flow ecosystem needs, nor should it. Native communities are adapted to meet periods of stress that occur within the natural ranges of frequency and duration. The Natural Flow Paradigm recognizes that rare natural extremes such as flood and droughts have important functions in supporting riverine ecosystems. Protecting flow variability is necessary to insure that the ecosystem provides the variety of habitat conditions necessary to support the entire ecosystem. Water management measures will be required where our uses increase the durations or frequencies of flow conditions below specified flows.

Protected Instream Flow Assessment

Defining protected instream flows begins with identification of the entities identified in statute for protection. Using a list of the general types of river features described in statute, a preliminary list of river-specific entities is generated from electronic mapping sources, personal interviews and study reports. The Designated River is then surveyed to confirm specific occurrences of these entities and identify others that are present. The list is then divided into flow-dependent and not-flow-dependent groups.

Assessment techniques are chosen to determine the flow needs for the flow-dependent members in the protected entities list. Assessment methods differ depending on the entity type. Assessment methods are selected that are appropriate for the type of entity being assessed. Assessment methods can be divided between those for human uses, for fish and aquatic life, and for riparian wildlife and vegetation.

Human Use Assessments Using Surveys and Questionnaires

Flow-dependent human uses of the river include both recreational (boating and swimming) and non-recreational (public water supply) uses. The instream flow needs for the recreational uses were assessed by surveys and questionnaires. These human-related instream flow needs are usually specific to the particular activity and the desired flow varies in a relatively narrow range throughout the year. These flows are not always available, resulting in the seasonal use of the river for recreation (boating or swimming). These are traditionally opportunistic uses, such that kayakers and swimmers use the flows when they occur, but do not expect these flows to be continuously available.

Boating on the Lamprey River includes both flat-water and whitewater. Running the entire designated segment involves both types of experiences and requires a sufficient flow so that paddlers can pass through the rapids sections unimpeded. Based upon information gathered as part of this study a flow of 275 cfs is probably required to support recreational boating of the full length of the designated segment. Boaters only using the flat-water sections stated that the only flow limitation to their use of these sections of the river were high (flood) floods, which create dangerous conditions. In the context of the Natural Flow Paradigm, the opportunity for boating the entire length of the designated segment is dependent upon the natural availability of the supporting flow. This flow is dependent upon runoff and groundwater recharge, which is affected by climate, but may also be affected by dam operations and/or water withdrawals along portions of the designated segment. The impact of any water uses on the magnitude, frequency and timing of flows that might affect boating recreation may be further investigated as part of the Water Management Plan process.

Based on the results of interviews, swimming at the designated beaches along the designated segment is dependent upon a number of variables; water level, flow velocity, water quality (temperature and appearance) and weather conditions (air temperature). As a result, all of the supporting conditions must be in place to favor swimming in the river. Since depth and velocity of flow of the river is highly dependent upon an individual's perception and preferences a protected instream flow value for swimming is not proposed for the designated segment.

Relative to water use by public water supplies, in 1965, the New Hampshire legislature enacted Chapter 332 regarding the use of the Lamprey River as a water supply by the towns of Durham, Epping, Lee, Newmarket and Raymond. Under this law, all of these towns *"shall have the use of the waters of the Lamprey River and its tributaries within said towns for the purpose of public water supplies to the exclusion of all other municipalities."* Of these communities only the towns of Durham and Newmarket have public water systems located along the Lamprey Designated River segment.

Water use by the public water supplies for these two towns was evaluated by questionnaires and interviews along with a review of their reported water use on file with DES. The UNH/Town of Durham water system withdraws water from the Lamprey River from a pump station located in the impounded section of the river upstream of Wiswall Dam. The amount of water withdrawn from the river by UNH/Durham is restricted by flow-dependent guidelines established as part of an existing 401 Water Quality Certificate issued by DES in 2001. The Town of Newmarket has withdrawn water from the Lamprey and two of its' tributaries (Folletts Brook and the Piscassic River) in the past, but stopped withdrawing water from these sources due to the cost of water treatment. The Town of Newmarket has received a Groundwater Discharge Permit to artificially recharge the aquifer that supplies its two production wells. The proposed source of this water would be a direct withdrawal from the designated segment.

Provisions in the existing 401 Water Quality Certificate for the UNH/Town of Durham water withdrawal and the conditions included in the Groundwater Discharge Permit for the Town of Newmarket's artificial recharge project establish limitations on either the amount of water that can be withdrawn or the timing of withdrawals from the designated segment. In addition to these limitations, water withdrawals from the designated segment of the Lamprey River may be limited to maintain the protected instream flows.

Should water withdrawals from the designated segment be needed to alleviate emergency conditions, Chapter 483 (New Hampshire Rivers Management and Protection Program) includes provisions for this emergency use. Specifically, Chapter 483:9-c states that "the protected instream flow levels established under this section shall be maintained at all times, except when inflow is less than the protected instream flow level as a result of natural causes or when the commissioner determines that a public water supply emergency exists which affects public health and safety." A provision for the emergency use of water by UNH/Durham is also included in its existing 401 Water Quality Certificate.

Aquatic Life Assessments and Riparian Assessments

Water use by fish and riparian wildlife and vegetation is different from human use. Fish and riparian wildlife and vegetation use are time dependent. Their life cycles require differing flows through the year. Assessment of riparian wildlife and vegetation flow needs uses a floodplain transect method that compares their bank elevations to the magnitude of flow needed to inundate those elevations. Flow timing, frequency and duration are keyed to life cycle needs. Assessment of fish and aquatic life flow needs uses a habitat simulation model called MesoHABSIM. Factors of habitat suitability are mapped at multiple flows. Habitat availability is defined relative to flow. Criteria for instream flows are then defined based on the timing, duration, and frequency of the flow magnitudes that maintain those levels of habitat availability.

Fish and Aquatic Life Assessment Using MesoHABSIM (habitat simulation model)

Flow requirements for fish, aquatic life and benthic invertebrates were developed using the MesoHABSIM model. The MesoHABSIM model establishes the river-specific relationship between stream flow and habitat availability. The model evaluates the time distribution of habitat availability to identify significant changes in habitat frequency and duration. Protection is identified that will limit flows below these significant changes in habitat frequency and duration.

MesoHABSIM is an adaptation of PHABSIM habitat simulation model. Both models assume that habitat availability correlates positively with population. Both are methods of evaluating habitat change relative to stream flows. MesoHABSIM takes measurements at a biologically-significant scale that is more representative of watershed-wide conditions. This shift in scale is a response to criticisms of the PHABSIM method, which extrapolates micro-scale habitat measurements made at selected cross-sections to the watershed. Because of this extrapolation from micro-scale to watershed scale, site selection is critically important in the PHABSIM method. MesoHABSIM addresses this criticism by evaluating representative reaches. The representative reaches are selected by quantitative assessment of their hydromorphologic makeup (pools, riffles, runs, etc.) relative to the river's makeup as a whole. Each representative reach is a microcosm of a larger segment. The representative reaches assessed for the Lamprey model comprised 55 percent of the Designated River, which is significantly greater than assessed by equivalent PHABSIM studies. Further, MesoHABSIM uses a greater number of biologically-significant criteria as inputs for evaluating habitat than PHABSIM, which generally uses depth and velocity. These two factors play the greatest role in habitat suitability when habitat is severely limited. MesoHABSIM measures habitat criteria at multiple locations within each type of stream hydromorphologic unit within the representative reaches. The MesoHABSIM method also then uses logistic regression of these factors to select the most significant for defining habitat suitability.

The underlying assumption of MesoHABSIM is that over many centuries biota adapted to their environment and that there is a strong functional relationship between the fauna composition and the physical form and structure of surrounding environment. We build upon a theory of biophysical habitat templates and corresponding biological communities (Poff and Ward 1990, Townsend and Hildrew 1994), which basically states that in natural environment every niche is used by some species and the fauna is adapted to predictable conditions.

Because in this way the physical structure shapes the fauna composition, we reverse this concept to identify the needs of the fauna by investigating characteristics of the physical habitat template. In our approach we identify habitat limitations by finding when the condition is so seldom that it becomes unpredictable.

Human interference tends to increase the frequency of unpredictable events (e.g. droughts) creating a mismatch between biological and physical templates. Hence, the determination of flow patterns that would be protective to the fish fauna is very limited using heavily modified flow patterns for this purpose. Therefore, the prerequisite of this approach is that the physical template will be as close to natural as possible under current climatic land use conditions.

Hence, to establish the baseline for the PISF determinations, we first need to calculate flows as they would occur in the river without human interference (withdrawals). Furthermore, we needed to take into account the physical modifications of the river channel as they also may create unpredictable habitat levels. Impoundments for example do not have features that would support fluvial fish and therefore need to be removed from the template describing predictable conditions. With an established baseline we can identify the habitat levels and corresponding flows that are seldom and establish PISF thresholds.

To carry out the MesoHABSIM model, a Target Fish Community is established for the river to identify the species expected in the Lamprey River. These data show the critical species and the timing of their life-cycle flow needs. These species are identified from fish data collected from near-pristine rivers with similar characteristics to the Lamprey.

Fish species in the Target Fish Community are evaluated to define their significant life-cycle phases throughout the year. The Lamprey River study identified six major life-cycle phases. These significant life-cycle phases are called bioperiods. Each is a biologically-significant phase for one or more of the species identified in the Target Fish Community. Protected instream flows are determined for each bioperiod. This defines the timing component of protected flows for fish.

To determine the protected flow magnitude, duration and frequency for a bioperiod, the natural availability of habitat is determined. Habitat preference criteria are developed for fish species and life stages. The habitat needs of the fish species are evaluated individually and collectively to define their criteria for habitat suitability. Using these criteria, the river is assessed for its suitability as habitat by making repeated measurements of habitat parameters within representative reaches at multiple flows. The suitability criteria are compared to conditions in the river. The relationship between flow and habitat is defined.

Although flow is related to habitat availability it is not a linear relationship. The flow-habitat relationship is used to transform stream flows over time into habitat over time. From long term records of naturalized flows, a daily record of available habitat is established. These records include years of habitat availability for each bioperiod.

Habitat availability within the designated reach for each bioperiod is assessed using time-series analysis. Time series analysis identifies the duration and frequency of habitat availability at incremental levels of habitat availability. The years of habitat availability show the range of habitat availability and the frequency and duration that habitat occurred. The analysis identifies habitat limitations and habitat magnitudes that demarcate drastic changes in frequency (e.g., sudden changes in habitat availability). For each of these habitat levels frequency analysis is also used to identify durations that are unusual and identify a series of thresholds that differentiate highly predictable or typical conditions from persistent and catastrophically long habitat shortages.

Three of these instances, marking significant changes in the frequency of habitat availability, are selected to represent the protected flows. These habitat availability levels are converted from habitat back to flow using the relationship between habitat availability and flow. These flow/habitat magnitudes and their associated durations representing significant changes in frequency are the protected instream flows for fish (Table 1).

Protected instream flow values described as magnitude and duration are defined for each of the six bioperiods during a year. The frequency assessment is incorporated in the selected magnitudes. The three flow magnitudes of protected instream flows are named: common, critical, and rare.

> The **common flow** is the flow corresponding to the highest habitat magnitude above which the frequency of occurrence begins to decline significantly with incremental increase in habitat magnitude.
>
> The **critical flow** is the flow corresponding to the second to the lowest habitat magnitude for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude. Critical flow magnitudes describe less habitat availability than that provided by the common flow, but this habitat magnitude is not unusual.
>
> The **rare flow** is the flow corresponding to the lowest of habitat magnitudes for which the frequency of occurrence increases significantly with incremental increase in habitat magnitude. Rare flow habitat availability is severely reduced and very uncommon.

Each flow magnitude is further characterized by two durations: allowable and catastrophic. The durations define limits on the consecutive days when flow is below a protected flow magnitude. Stream flow at levels below a protected magnitude for durations shorter than the allowable duration is acceptable, and is a common condition. Flow below a protected magnitude for durations longer than the catastrophic duration is unacceptable and triggers management. Flow below a protected magnitude for more than the allowable duration, but less than the catastrophic duration is a persistent condition. A persistent condition that occurs for three consecutive years within the same bioperiod is a catastrophic condition and triggers management on the inception of an event on that third occurrence. Flow durations are reset by a two-day increase in flow above the next higher flow magnitude threshold. These reset events can be naturally or artificially created increases. Flow durations are reset at the beginning of a new bioperiod.

Flow protection describing high flow limits are for management activities only. Naturally occurring flows are not managed. High flows created by management activities such as releases from impoundments are limited by these criteria.

Protected Instream Flows for Fish and Aquatic Life

The above methodology has been applied to identify protected flows for each of six bioperiods. The recommendations consist of flow magnitude in cfs and cfsm as well as allowable and catastrophic durations. These prescriptions are intended to be used to determine whether flow management actions are necessary and the magnitude of flows associated with the actions. The exceedence of the allowable durations below the specified flows magnitudes calls for management activities.

Table 1 - Protected instream flow criteria for fish in the Lamprey Designated River

Bioperiod Approximate dates	Rearing & Growth July 5 - Oct. 6	Salmon Spawning Oct. 7 - Dec. 8	Overwintering Dec 9 - Feb. 28	Spring Flood March 1 - May 4
Indicator	Common shiner	Atlantic Salmon	Flow	Flow
Watershed area (mi^2)	183	183	183	183
Common flow (cfs)	110	90	237.9	622
Common flow (cfsm)	0.60	0.49	1.30	3.40
Allowable duration under (days)	46	17	20	14
Catastrophic duration (days)	81	55	57	42
Critical flow (cfs)	22	40	109.8	238
Critical flow (cfsm)	0.12	0.22	0.60	1.30
Allowable duration under (days)	15	11	10	10
Catastrophic duration (days)	32	33	37	19
Rare flow (cfs)	16	20	73.2	146
Rare flow (cfsm)	0.09	0.11	0.40	0.80
Allowable duration under (days)	6	6	7	3
Catastrophic duration (days)	28	11	30	9

Bioperiod Approximate dates	Clupeid Spawning May 5 - June 19		GRAF Spawning May 5 - July 14	
Indicator	Min	Max	Min	Max
Watershed area (mi^2)	183	183	183	183
Common flow (cfs)	143		101	
Common flow (cfsm)	0.78		0.55	
Allowable duration under (days)	13		11	
Catastrophic duration (days)	28		15	
Critical flow (cfs)	62	156	22	156
Critical flow (cfsm)	0.34	0.85	0.12	0.85
Allowable duration under (days)	5		5	
Catastrophic duration (days)	13		10	
Rare flow (cfs)	57	242	16	242
Rare flow (cfsm)	0.31	1.32	0.09	1.32
Allowable duration under (days)	4		2	
Catastrophic duration (days)	10		3	

GRAF Spawning	Common shiner R&G

Riparian Wildlife and Vegetation Using the Floodplain Transect Method

Protected instream flow requirements for wetlands, floodplains, and channel habitats and their associated flora and fauna were determined by surveying transects across the river channel and floodplain. This method uses an entity's elevational position on the stream bank to determine flow magnitudes based on the flow that occurs at this water level. Life cycle needs are determined by species to describe frequency and timing of these flows.

Cross sections and maps are constructed showing plant community boundaries and wildlife habitats associated with their topographic position. Surface water elevations along the transect during low, moderate and high flow events and simultaneously stream flows from gage stations are recorded and added to the transect cross-section. Protected instream flows are defined as those flows associated with the water level at each plant community or habitat that is critical during important life cycle events – for example:

- Filling oxbow/backwater marshes, swamps and floodplain pools during spring for plant development and breeding wildlife.
- Maintaining sufficient water cover over hibernating turtles and amphibians over the winter.
- Scouring of floodplain forest floors once every three years to discourage invasive species and prepare seedbeds.

Protected flows are defined under the floodplain transect method using the magnitude, timing, and frequency of flows needed to support riparian wildlife and vegetation. In addition, there are plant communities and species that are sensitive to high flows occurring during bioperiods typically associated with low flows. For example, turtle and bird nests located in the high floodplain could be destroyed by flooding that occurs during the nesting season when flows are typically low. These sensitive entities are discussed in this report to inform flow managers contemplating management decisions that might result in unnatural flood events (such as a dam release); it is not intended to imply that naturally occurring floods, regardless of timing, be controlled for the protection of these particular sensitive resources.

Protected Instream Flows for Riparian Wildlife and Vegetation

Protective flows vary greatly among the numerous plants, natural communities, and wildlife species associated with the Lamprey River riparian corridor. To facilitate discussion, flow-dependent riparian entities can be sorted into five primary groups with similar flow needs:

1. Periodic Flood PISF (annually or less in frequency)
2. Minimum Seasonal PISF (every winter, spring, and/or summer)
3. Maximum summer PISF
4. General Reference Adult Fish (fish) PISF (for eagles, osprey)
5. PIS water levels (not flows)

Group 1 includes high and low floodplain forests and oxbow/backwater swamps that depend on periodic flooding (annually or less often) to fill basins, deposit nutrients, and eliminate flood intolerant plants. Depending on landscape position, these communities may flood once a year to once every hundred years, occurring typically in late winter/early spring, for days to weeks (Table 2). Flows that are greater than 500 cfs every one to three years, and flows that are at least 1,500 cfs once every five years (with greater flows occurring less frequently) are typical under natural conditions, based on tree flood tolerance data, plant community descriptions, and soil characteristics. There is no intent to suggest creating floods for these entities, nor should such flood events be deliberately prevented through management practices.

Group 2 includes the in-stream plants and communities that have annual minimum winter, spring and early summer flows to set up optimum conditions for early vegetative growth and development. Herbaceous low riverbanks, Riverweed river rapids, and marshes, along with their associated RTE plants are in this group, as well as hibernating wood turtles which have minimum flow requirements in winter. Minimum monthly flows that are protective of all of these entities are 130 cfs from December through March, 100 cfs April through June, and 10 cfs during July (Table 2). During the winter, daily flows should be at least 50 cfs, and flows of 500 cfs should occur for at least one week. These flows occur naturally in most years, and should not be prevented by management activities.

Group 3 are the plants and animals that are sensitive to the rare summer flood events. Turtle eggs and nestlings in the high floodplain, larval amphibians in floodplain pools, and blooming aquatic and emergent plants may be harmed by summer floods. Daily flows that are less than 500 cfs in June, July and October, and are less than 60 cfs in August and September are protective of all of these entities (Table 2). However as previously stated, these sensitive entities are discussed in this report to inform regulators contemplating management decisions that might result in unnatural flood events (such as a dam release); it is not intended to imply that naturally occurring floods, regardless of timing, be controlled for the protection of these particular sensitive resources.

Group 4 are the fish-eating raptors, including bald eagles and osprey that may feed in the Lamprey River at any time of year. The flows protective of these species are those of the General Reference Adult Fish (GRAF) fish as discussed in the fish section of the report.

Group 5 includes the plants and animals of the larger impoundments of the Lamprey. They include pied-billed grebes, sedge wren (neither of which were observed) and the aquatic plants water marigold and star duckweed. Protective flows for these species were not determined, as their required water levels are not well correlated with changes in flow in these impoundments. Instead, protective water levels were identified. These are summer water levels within 18 inches of the mean, with no reductions exceeding six inches for more than seven days from March 15 through July 31.

Table 2 - Protected Instream Flows for Riparian Wildlife and Vegetation on the Lamprey Designated River

Protected Entities	Conservation Status[1]	General Location	Sensitive Bioperiod(s)	General Flow Requirements.	PISF (at Lamprey Gage)
Low Floodplain Forest	S2	Newmarket pool, scattered elsewhere	Growing season	One to three year flooding (< two year return flood)	>500 cfs every one to three years for five to 50 days.
High Floodplain Forest (incl. Swamp White Oak *Quercus bicolor*)	S2S3 S1	Narrow band along most of Lamprey, wider at tributaries and oxbows.	Growing season	Two to 100 year flooding (>two-year return flood)	> 1,500 cfs every two to 100 years for five to 30 days
Oxbow/Backwater Swamp	S3	North of Glenmere Village	Growing season	Flooding of backwaters/oxbows	>1,500 cfs every one to five years
Herbaceous Low Riverbank	S3/S4	Near Lee Hook Road and other locations	Winter/Spring dormancy	Flood/ice scour of channel	December 1 to April 30 >500 cfs for one week
			Late summer flowering	Low flow to expose substrate	August 1 to September 30 $\leq$ 60 cfs mean daily flow
Riverweed River Rapid	S2S3	Near Lee Hook Road and other locations	Spring growth	Flooding of riffles	May 1 to June 30 >100 cfs mean monthly flow
			Late summer flowering	Low flow to expose riffles	August 1 to September 30 < 100 cfs mean monthly flow
Deep and Shallow Marsh	S4S5	Along tributaries and in pools above dams	Early-mid growing season	Flooding of marsh for dependent fauna	April 1 to July 31 >10 cfs daily mean flow

Protected Entities	Conservation Status[1]	General Location	Sensitive Bioperiod(s)	General Flow Requirements.	PISF (at Lamprey Gage)
Vernal Floodplain Pool	S2	Near Wiswall Rd and Glenmere Village	Early spring to mid-Summer breeding season	Hydrologic isolation of pools in high floodplain	March 15-July 31 <1,500 cfs every day
			Early spring to mid-Summer breeding season	Maintain hydrology of river-connected pools in low floodplain	March 15-July 31 No impoundment drawdown > six inches for more than seven consecutive days
Climbing Hempweed *Mikania scandens*	G5S2	Tributary Stream floodplain	Spring/Summer growing season	Forested wetland hydrology	April 1 to October 31 >500 cfs for 10 days (non-consecutive)
Star Duckweed *Lemna trisulca*	G5S1	Tributary Stream	Summer growing season	Maintain standing water or saturation	No PISF[3]
Water Marigold *Megalodonta beckii*	G4G5S1	River/Tributary Impoundments	Summer growing season	Maintain standing water	No PISF[1] Maintain summer water levels within two feet of mean elevation.
Knotty Pondweed *Potamogeton nodosus*	G4G5S1	River/Tributary Impoundments	Early summer growth	Maintain flowing water	May 1 to June 30 >100 cfs mean monthly
	G5S1	Fast shallow water	Late summer flowering	Low flowing water	August 1 to September 30 <100 cfs mean monthly
Slender Blueflag *Iris prismatica*	G4G5S2	Floodplains, riverbanks	Growing season	Maintain wetland hydrology	See requirements for shallow marsh
Sharp-flowered Mannagrass *Glyceria acutiflora*	G5S1	Fast shallow water	Growing season	Maintain wetland hydrology	See requirements for herbaceous low riverbank

Protected Entities	**Conservation Status**[1]	**General Location**	**Sensitive Bioperiod(s)**	**General Flow Requirements.**	**PISF (at Lamprey Gage)**
Blanding's Turtle *Emydoidea blandingii*	G4S3 Special Concern[2]	Uplands near Backwater/oxbow wetland complex	Spring-summer nesting season	No flooding of high floodplain nest sites	June 1 to October 31 <1,500 cfs daily flow
Wood Turtle *Clemmys insculpta*	G4S3 Special Concern	Uplands and floodplains near Tributary streams	Spring-summer nesting	No flooding during nesting in mid to high floodplain	June 1 to October 15 <500 cfs daily flow
		Lamprey River and Tributary streams	Winter hibernation	Avoid dewatering of in-channel hibernation sites	December 1 to March 31 >130 cfs seasonal mean >50 cfs daily mean
Spotted Turtle *Clemmys guttata*	G5S3 Special Concern[2]	Uplands near Backwater/oxbow/VP wetland complex	Spring-summer nesting	No flooding of high floodplain nest sites	June 1 to October 31 <1,500 cfs daily flow
Osprey *Pandion haliaetus*	G5S2B State-Threatened[2]	Pools in lower Designated reach	Spring-summer nesting-rearing	Sufficient flows to protect prey (fish) in channel	Support prey fisheries (see GRAF Fish recommended flows)
Bald Eagle *Haliaeetus leucocephalus*	G5S1 State-Endangered[2]	Pools in Lower designated reach	Any time of year	Sufficient flows to protect prey (fish) in channel	Support prey fisheries (see GRAF Fish recommended flows)
Pied-billed Grebe *Podilymbus podiceps*	G5S1B State-Endangered[2]	Large emergent marshes in impoundments	Spring-summer nesting	Maintain water levels during nesting season	No PISF[3]. Maintain summer water levels within two feet of mean elevation.
Sedge Wren *Cistothorus platensis*	G5S1 State-Endangered	Wet meadows near impoundments	Spring-summer nesting	Maintain water levels during nesting season	No PISF[3]. Maintain summer water levels within 18 inches of mean elevation.

1 **– G=Global Rank; S=State Rank; Numerical status is:**

Code	Description
1	Critically imperiled because extreme rarity (generally one to five occurrences) or some factor of its biology makes it particularly vulnerable to extinction.
2	Imperiled because rarity (generally six to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.
3	Either very rare and local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction because of other factors.
4	Widespread and apparently secure, although the species may be quite rare in parts of its range, especially at the periphery.
5	Demonstrably widespread and secure, although the species may be quite rare in parts of its range, particularly at the periphery.
B.	Indicates that the species is migratory and breeds in the state.

2 – On June 25, 2008 the New Hampshire Fish and Game Department proposed the following changes to the protection status for these (and other) species:

Blanding's Turtle – added to the Endangered Species List
Spotted Turtle – added to the Threatened Species List
Osprey – removed from the Threatened Species List
Bald Eagle – down listed from Endangered to Threatened
Pied-billed Grebe – down listed from Endangered to Threatened

3 - These species are dependent on minimal standing water or water levels that are not greatly altered by changes in flow, and therefore, no PISF was assigned to them. They may, however, be vulnerable to rapid or prolonged changes in water levels associated with dam management. See text for more details

Flow protection describing high flow limits are for management activities only. Naturally occurring flows are not managed. High flows created by management activities such as releases from impoundments are limited by these criteria.

Proposed Protected Instream Flows for the Lamprey Designated River

From comprehensive analysis of Protected Instream Flow needs for investigated protected entities we concluded that the flows necessary to support instream fauna are fulfilling the criteria for all non-opportunistic water users (Table 1). This determination comes from comparing the timing and magnitude of the flow needs for fish, riparian vegetation and wildlife and human uses. The emphasis of this comparison was to determine the highest flow need of all entities in order to define the controlling flow. By satisfying the highest flow, all other flow needs are then met. The selection of the highest flow need as the protected flow magnitudes are tempered by the description of allowable and catastrophic “under threshold” durations keyed to their natural range of occurrence. However, specific interannual flow needs of entities other than fish are incorporated in PISF recommendations.

Comparison of daily stream flow at an index location to the protected instream flow conditions determines when flow management should be conducted under the Water Management Plan. For the Lamprey River, the index location for tracking protected flows is the USGS stream flow gage at Packers Falls near Newmarket. The proposed protected flows are described in cubic feet per second (or cfs) at the gage One cfs is equivalent to 449 gallons per minute or 0.65 million gallons per day. Protected flows may also be described in terms of flow per unit area as cfs per square mile of drainage area (cfsm). Using this term, the proposed protected instream flow can be prorated to upstream and downstream locations from the index location.

The recommended protected instream flow for recreation is 275 cfs, which in an average year is met 37 percent of time. If this human-related instream flow were to be the controlling instream flow, the protected flow for the Lamprey River would be equal to the flows occurring only during spring snowmelt runoff, during the fall when water stored in Pawtuckaway Lake is released and/or during large storm events and as a result would not be continuously sustainable. As described earlier, the recreational use arose with the expectation of only a certain frequency of flows available at these magnitudes. The number of days of occurrence of flows equal to 275 cfs will be tracked to ensure that the frequency of these events continues to match historical occurrence rates. So the instream flow need for this use will continue to be met as it has been traditionally (that is, opportunistically) and the management strategy will consider this flow in the context of preserving the frequency of its occurrence, but will not attempt to meet recreation needs on a continuous basis.

The flow requirements for fish as determined by the MesoHABSIM model and riparian wildlife and vegetation as determined by the floodplain transect method were identified as the controlling flow needs. In the case of Lamprey River, the defining proposed protected instream flows are those for fish (see Table 1). The requirements of riparian wildlife and vegetation (see Table 2) are either lower than those of fish or need to be fulfilled on an inter-annual basis (i.e. every three years).

From comprehensive analysis of Protected Instream Flow needs for investigated protected entities we concluded that the flows necessary to support instream fauna are fulfilling the criteria for all non-opportunistic water users. The needs of riparian wildlife and vegetation that are not obviously secured by fish specific flows are:

Winter Survival and Development - December 1 through April 30

>130 cfs seasonal mean – wood turtle

>500 cfs for one week or more – Herbaceous Low Riverbank, mannagrass, hempweed

Spring Spawning May 1 through June 30

>100 cfs seasonal mean – riverweed, knotty pondweed

<500 cfs daily mean in June except for natural events (wood turtle)

<1,500 cfs daily mean in May except for natural events - floodplain vernal pools

Summer Survival and Development – July 1 through Sept 30

<500 cfs daily mean in July except for natural events – wood turtle

≤60 cfs daily mean in August/Sept except for natural events – Herbaceous low riverbank

<100 cfs seasonal mean – August /Sept except for natural events – riverweed, knotty pondweed

The requirement for ≤60 cfs of daily mean in August and September for maintenance of herbaceous low riverbank conflicts to some extent with the needs of common shiner. During this time the flows for common shiner should fluctuate between 22 and 110 cfs. However, because the flows between 60 and 110 cfs will not occur very often we recommend that the criteria specified in the Table 1 should be used for development of water management plan.

The lowest naturalized flow recorded in last 30 years was 3.7 cfs at the Packers Falls gage. Hence, allowing flows to fall under this level creates unpredictable, catastrophic conditions that are not protective to the aquatic community. Therefore we recommend that the flows should never be allowed to fall below 4 cfs.

The proposed protected instream flows will be maintained by implementing Water Management Plans. Under the water management plan, management actions are implemented to offset catastrophic conditions. Implementation of management actions will be based on tracking river flows and comparing them to the protected instream flows. The instream flows defined for Fish and Aquatic Life are assessed on a day to day basis to determine whether flows below thresholds exceed catastrophic durations. Flows that continue below thresholds beyond allowable durations will be tracked. Repeated events occurring within successive bioperiods or occurring during the same bioperiod for three successive years represent persistent conditions. Persistent events are tracked on an inter-annual basis and will be deemed catastrophic if they occur in three consecutive years within the same bioperiod, with management actions triggered at the beginning of the onset of the third event under these flow conditions. Increased frequency of catastrophic events calls for long term measures such as habitat improvement that will reduce the recurrence interval of the catastrophic events.

The instream flows for Riparian Wildlife and Vegetation must be assessed over one or more years so management of these protected flows will react to the previous year's or years' conditions and apply flow protections the following year. If the watershed did not meet these instream flows, the management for the following year may include either storage to ensure stored water for pulses to meet the required flows or habitat increase through improvement of channel structure.